Northern Wisconsin Soil Moisture Study of Glacial Till Soils

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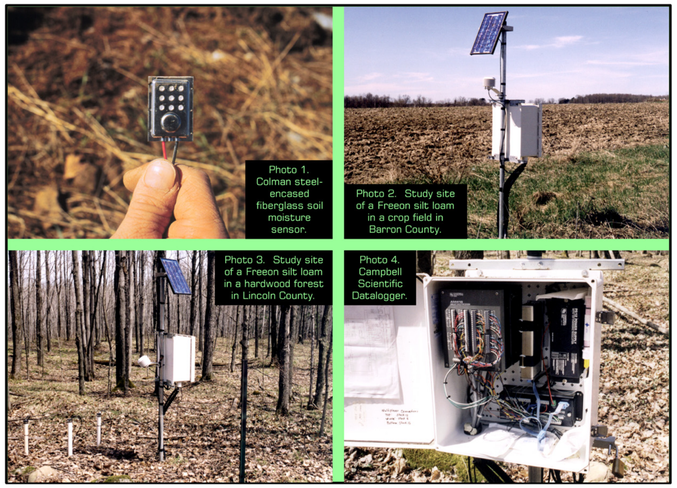


Photo 1. Colman steel-encased fiberglass soil moisture sensor.

Photo 2. Study site of a Freeon silt loam in a crop field in Barron County.

Photo 3. Study site of a Freeon silt loam in a hardwood forest in Lincoln County.

Photo 4. Campbell Scientific Datalogger.

Introduction

Northern Wisconsin has a large acreage of glacial soil that includes friable till, friable till with fragipans, and dense till. Questions arose concerning the available water capacity and saturated hydraulic conductivity of dense till since soil scientists were observing a definite wetting and drying pattern coincident with the seasons. In the past, Wisconsin had been instructed to show "zero" (or near zero) available water capacity and "very slow" permeability for horizons with bulk density of 1.8 or greater.

Planning for this project began in 1989, with the project to run about ten years after implementation. The objectives are to collect data on water retention and saturated hydraulic conductivity of both friable and dense till and to identify water movement over the landscape. The study includes collecting standard characterization data of the soil profile, field measurements of hydraulic conductivity, and installation of soil moisture and temperature sensors. The study sites selected include both forested and agricultural sites.

The goal of the project is to provide field measurements that will serve as a basis in developing accurate soil/moisture interpretations that reflect actual field conditions. The applications will not only be for dense till, but also for friable till and fragipans across northern Wisconsin. The resulting data will be used to populate soil moisture sections in the NRCS National Soil Information System (NASIS) for each soil studied. The data will also be used to show seasonal soil moisture fluctuations and availability to plants in relationship to landscape, micro-topography, and till fabric.

Figure 1. Wisconsin soil moisture study sites.

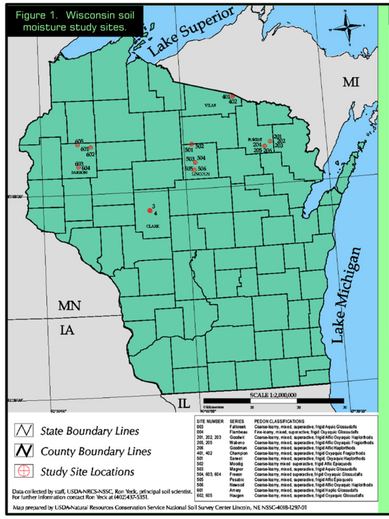


Figure 2. Monthly soil moisture pattern.

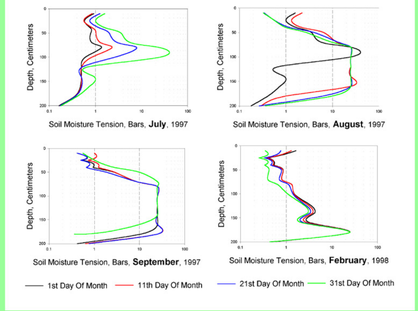
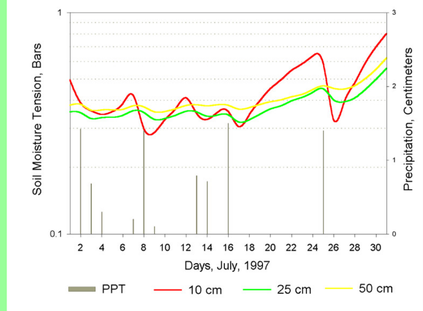


Figure 3. Soil moisture response to rain.



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Project

Figure 1 shows the study site locations along with the associated pedon classifications. The soils with friable till include the Fall Creek, Flambeau, Goodman, Goodwit, Sarwet, and Moodig series. The soils with fragipans include the Champion and Wabeno series. The soils with dense till include the Freeon, Magnor, Amery, Haugen, Newood, and Pesabic series.

At each site, resistance-type soil moisture sensors (Colman steel-encased fiberglass sensors – Photo 1) were installed at twelve depths (10, 25, 40, 50, 70, 85, 100, 120, 140, 160, 180, and 200 cm) in triplicate. At most sites, combination sensors for both soil moisture and temperature were installed at three depths (25, 50, and 200 cm). Two sites have combination sensors at all twelve depths. At two sites, piezometers (with automated water-level sensors) were installed with additional sites being planned. Sensor leads are attached to Campbell Scientific Dataloggers powered with solar-charged batteries (Photos 2, 3, and 4). The dataloggers collect data around the clock in 40-minute intervals, averages the readings on a two-hour basis, and stores the data in storage modules. The data are downloaded to laptop or palmtop computers four times a year. Saturated hydraulic conductivity was measured at each site with either a Guelph Permeameter or an Amoozemeter (Photo 5).

The dataloggers were installed at each site in 1995 and 1996. Prior to that, the sensors were connected to a rotary dial system with the data recorded manually 1 to 2 times per month (Photo 6). The rotary system had serious flaws that led to unreliable data, so they were replaced with dataloggers. Therefore, only 3 to 4 years of reliable data exists. This will extend the length of the project from its original plan.

Discussion

The project fieldwork began in 1990, but only 3 to 4 years of consistent data exists after the installation of the dataloggers. A general fluctuation in soil moisture and temperature, coincident with the seasons, is already expressing itself for each of the soils studied, including the dense till.

Figure 2 shows the soil moisture tension patterns with depth of one of the dense till sites. The graphs compare a time period of July through September with that for February. The sensors record soil retention as resistance and an algorithm is applied to convert to tension (Bars).

Figure 3 shows the response of soil moisture tension to precipitation. The soil moisture tension response time is detectable only with data collected at close intervals. At the 10-cm depth, the soil moisture tension decreases almost immediately after the rain, whereas the soil moisture tension at 25 cm did not change noticeably until the fifth day when the cumulative rainfall was 4 cm.

The measured soil moisture tension ranges from < 0.1 to > 15 Bar but never gets to 0.01 Bar. This would indicate that none of the soils studied ever reached saturation ≤ 0.01 Bar) in any horizon. Field experience from soil scientists working on soil surveys in northern Wisconsin claim otherwise. Photo 7 shows a backhoe pit of the Sarwet site on a low drumlin showing free water. (Sarwet is moderately well drained with friable till.) The sensors used do not appear to be sensitive enough to record resistance at the wet end of the spectrum. Therefore, several sites will be re-instrumented with newer, more-sensitive sensors while others will have automated piezometers installed. The piezometers will provide direct correlation of sensor readings with actual presence of free water. These upgrades are planned for 1999 and 2000.

Photo 8 shows a Freeon soil from an agricultural site. Freeon is a moderately well drained soil with less than a meter of brown silt loam loess over reddish-brown dense sandy loam till. The dense till in northern Wisconsin exhibits an inherent platy-like "structure" rather than a massive structure-less entity.

Since the implementation of this project, fractures in the dense till began to receive greater attention. Vertical and diagonal fractures in the dense till fabric was always known to exist, but were generally not described or considered to have much impact. Current consideration is that the fractures act as avenues of soil moisture movement downward into the dense till fabric, as evidenced by redoximorphic features and clay films along the walls of the fractures. From these fractures, soil moisture may then move horizontally into the till fabric between the inherently platy "structure". In order to verify the level to which the dense till may be fractured, the soils at each dense till site will by re-described via back-hoe pits to accurately identify the fracture features.

Conclusions

This project has been going through "growing pains" from the beginning, mainly because this type of study has never been attempted before on this scale. Still, a lot has been learned and verified with regards to soil/moisture relationships and with the installation and limitations of the measuring instruments. With the upgrades being planned, this study will be closer to measuring actual soil moisture conditions over time and can serve as a model for future projects. The data will provide a scientific basis for input into NASIS and for generating interpretations, and a greater understanding of seasonal soil moisture fluctuations for dense till versus friable till will be attained.

Photo 5. Measuring saturated hydraulic conductivity using an Amoozemeter.

Photo 6. Rotary Dial System used to collect data prior to the installation of the dataloggers.

Photo 7. Standing water in a Sarwet soil pit. The till is on a drumlin and is friable.

Photo 8. Profile of a Freeon silt loam.